A Study on Mobility in VDL Modes 2 and 3

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Study Overview

- Examine the handoff mechanisms of VDL Modes 2 and 3
- Determine the handoff delays of each of the two modes through simulation
  - Handoff delay is defined as the amount of time during which the data link is unavailable during the handoff procedure
- This study does not examine mobility mechanisms at the higher layers

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VDL Modes 2 and 3

- Mode 2
  - Carrier-Sense Multiple Access (CSMA)
  - No priority support
- Mode 3
  - Time-Division Multiple Access
    - Offers several 3 and 4 slot configurations
    - 120 ms frame length
  - Supports voice for ATC
  - Supports priority
- Both modes operate at 31.5 kbps

Mode 2 Handoffs

Five types of handoff are specified for Mode 2:

- Aircraft-Initiated
  - Used in light to moderately loaded subnetworks
  - The aircraft decides when to handoff based on signal quality or on link failure
- Aircraft-Requested Ground-Initiated
  - Used in moderately to heavily loaded subnetworks
  - The aircraft decides when to handoff based on signal quality
  - Allows the ground network to decide the next ground station for load balancing

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Mode 2 Handoffs (continued)

- Ground-Initiated
  - Used in heavily loaded subnetworks
  - The ground determines when to handoff and selects the next ground station for load balancing
  - Handoff must be to another ground station on the same frequency
- Ground-Requested Aircraft-Initiated
  - The ground determines when to handoff and selects the next ground station for load balancing
  - Similar to the Ground-Initiated handoff, but allows the aircraft to handoff to a ground station on a different frequency
- Broadcast
  - Allows the ground to initiate handoffs to multiple aircraft

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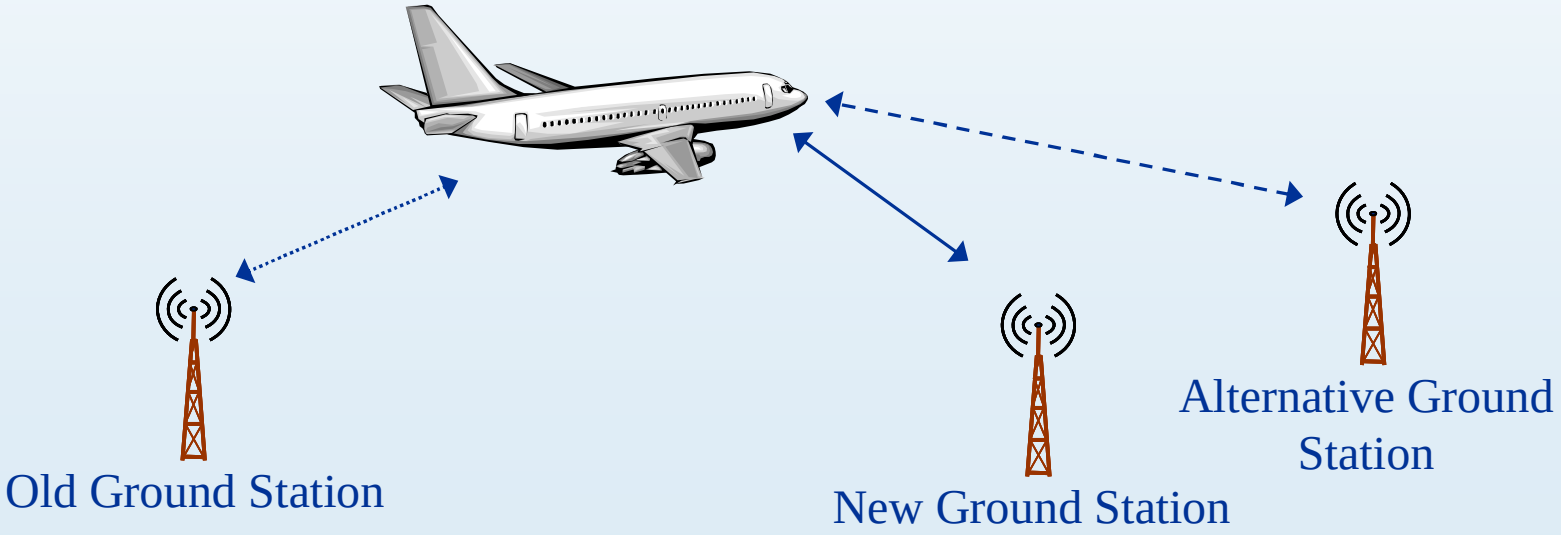
Mode 2 Handoff Scenario

- A Mode 2 handoff occurs based on signal quality and ground station load
- A handoff is possible to any ground station in the area with good signal quality



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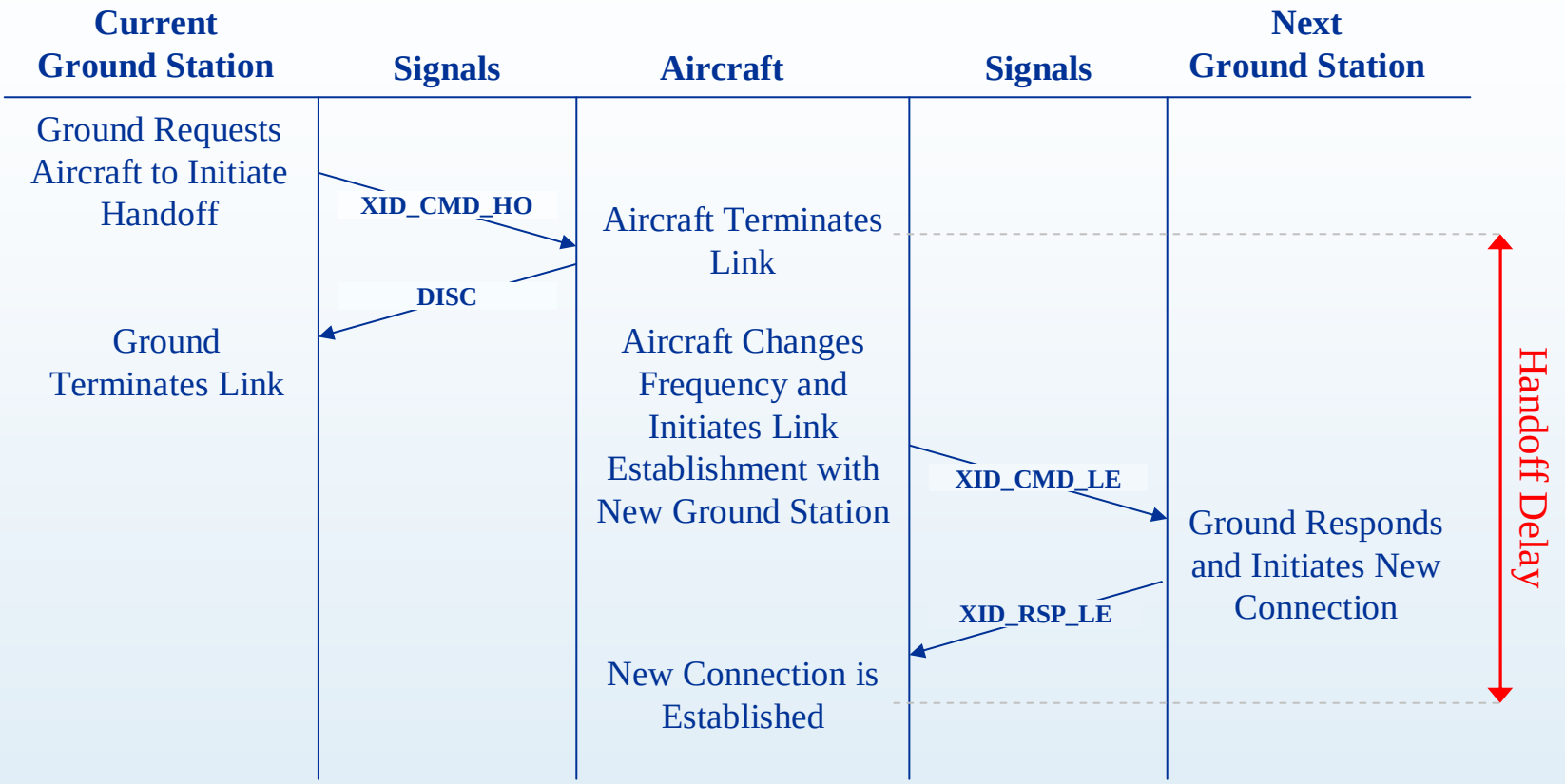
Example Mode 2 Handoff



Ground-Requested Aircraft-Initiated Handoff

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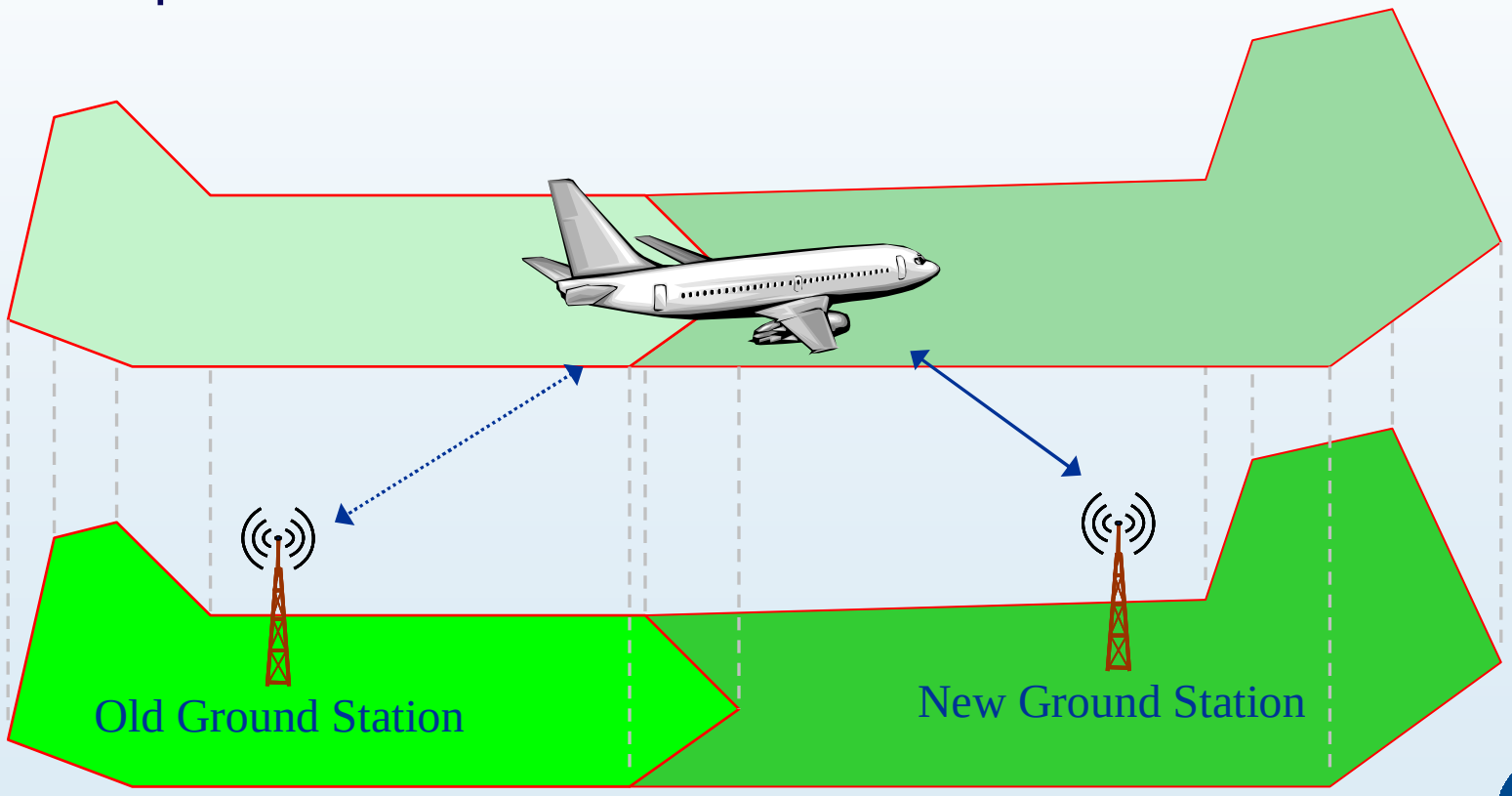
Mode 3 Handoffs

- Ground-Initiated
  - The ground informs the aircraft of the next frequency and group that should be tuned
- Aircraft-Initiated
  - Used when manually retuning the radio
  - Used by 3T configuration with auto-tune

Mode 3 Handoff Scenario

- A Mode 3 handoff occurs due to a sector transition
- A handoff is possible only to a specific ground station that provides service to the next sector



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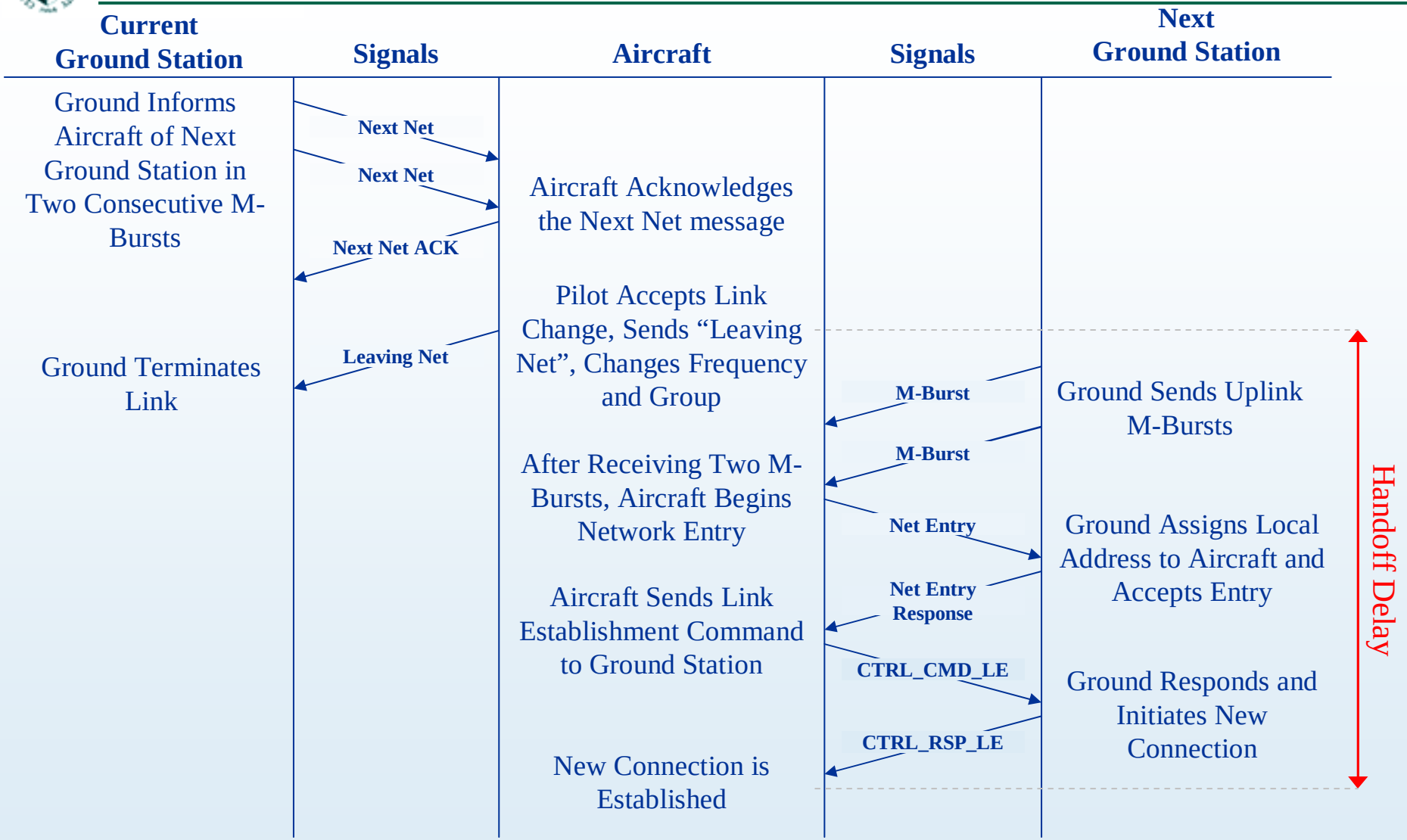
Example Mode 3 Handoff



Ground-Initiated Handoff

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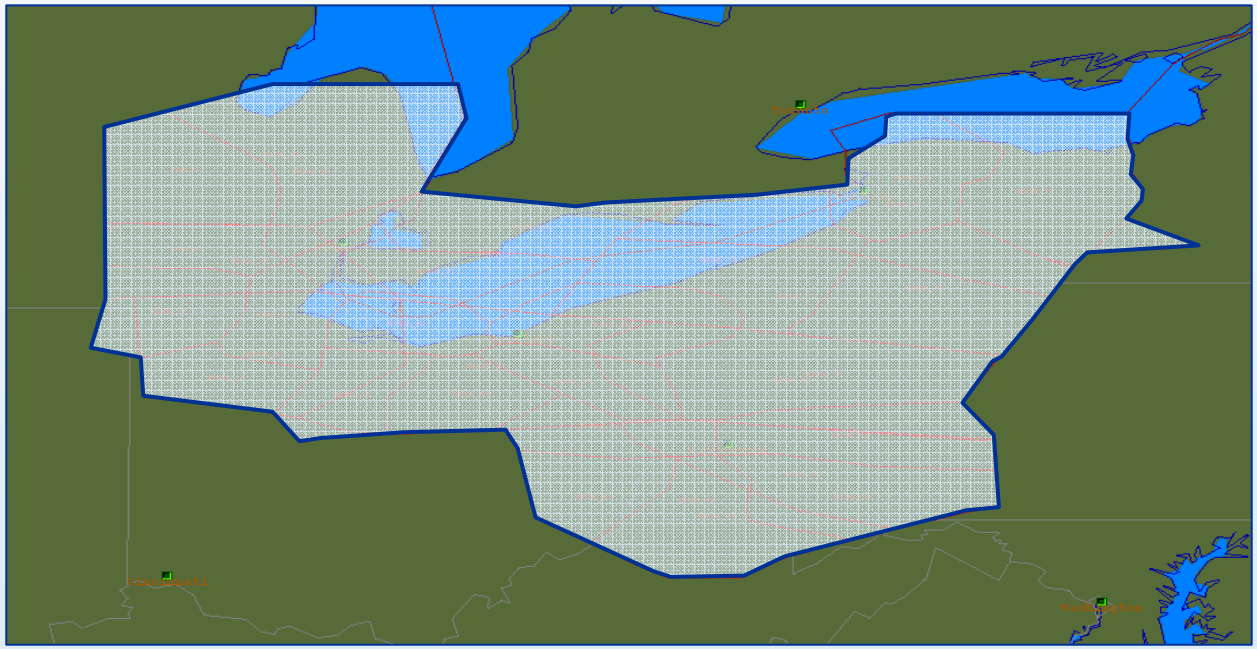
Simulation Scenario

- Models the Cleveland ARTCC
  - 48 en route sectors
  - 15 TRACONs
- Includes 218 flights over a 1 hour period
  - Flight trajectories are based on actual flight data



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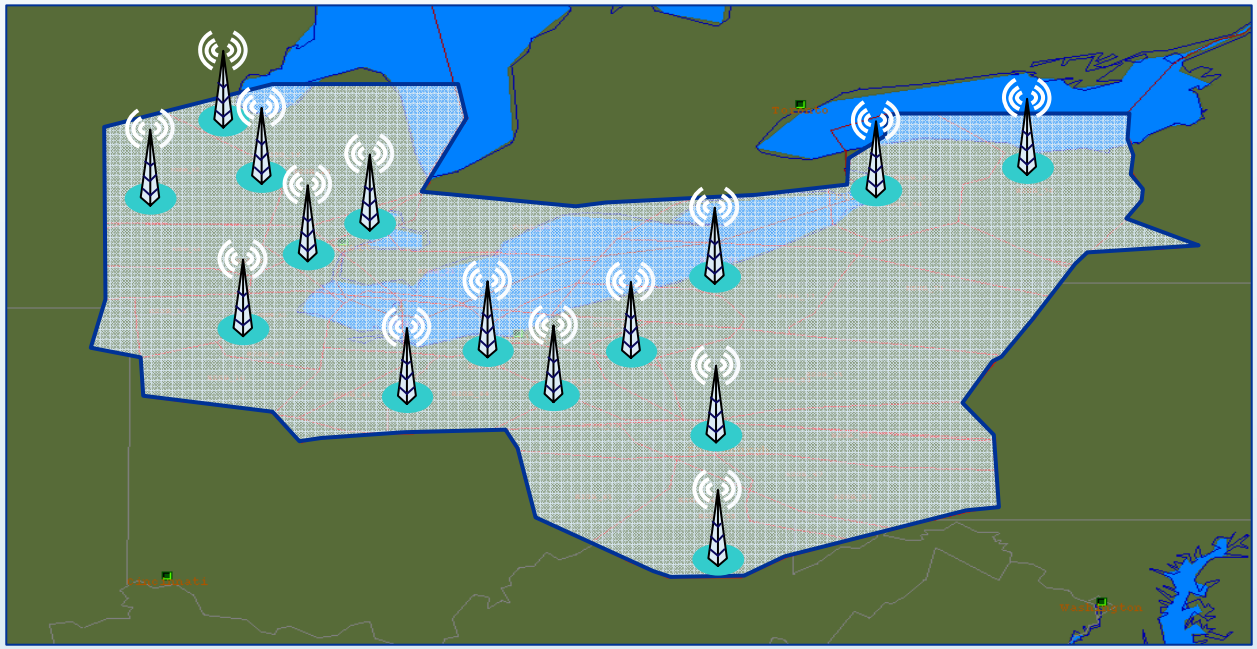
Simulation Scenario (2)

- 32 VDL ground stations included at 15 sites to provide coverage
  - Each ground station provides communications for 2 sectors
  - Sites are located at the TRACONs
- Each ground station belongs to a separate ground system
  - Excludes “soft handoffs” from this study



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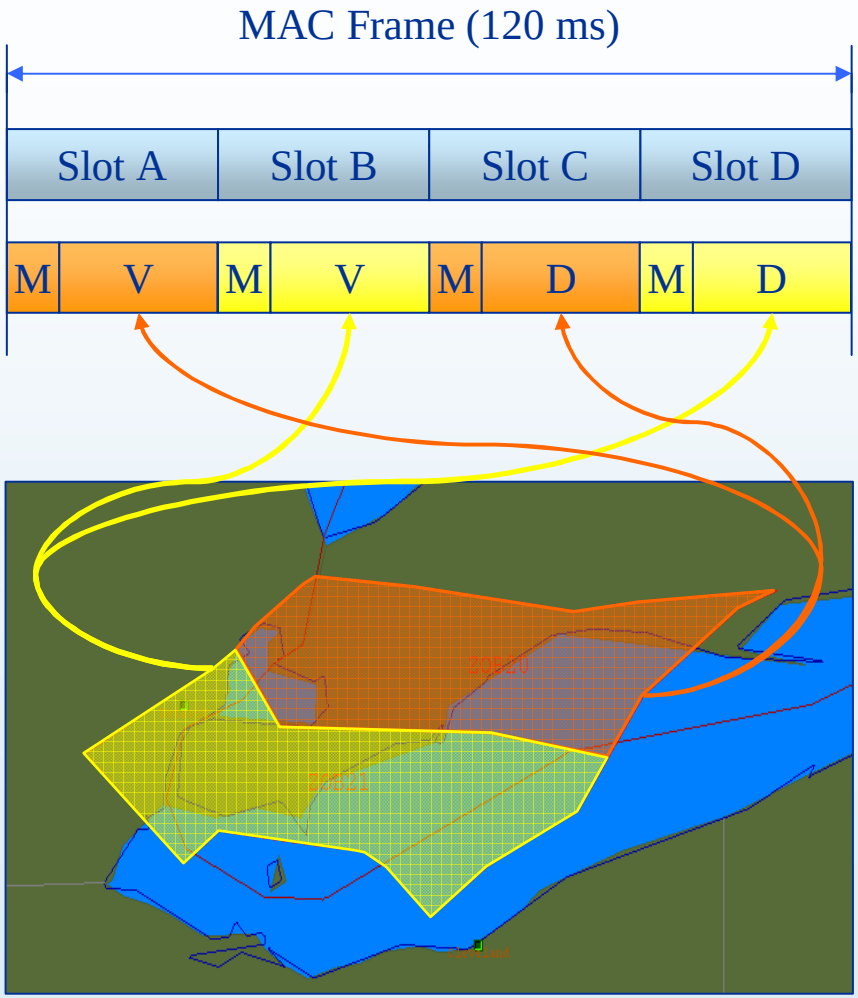
Simulation Scenario (3)

- All handoffs occur at sector boundaries
- Mode 3 operates in the 2V2D operation
- Basic services operate over the link to provide traffic
  - Includes CPDLC, DSSDL, AOCDL, and AUTOMET traffic

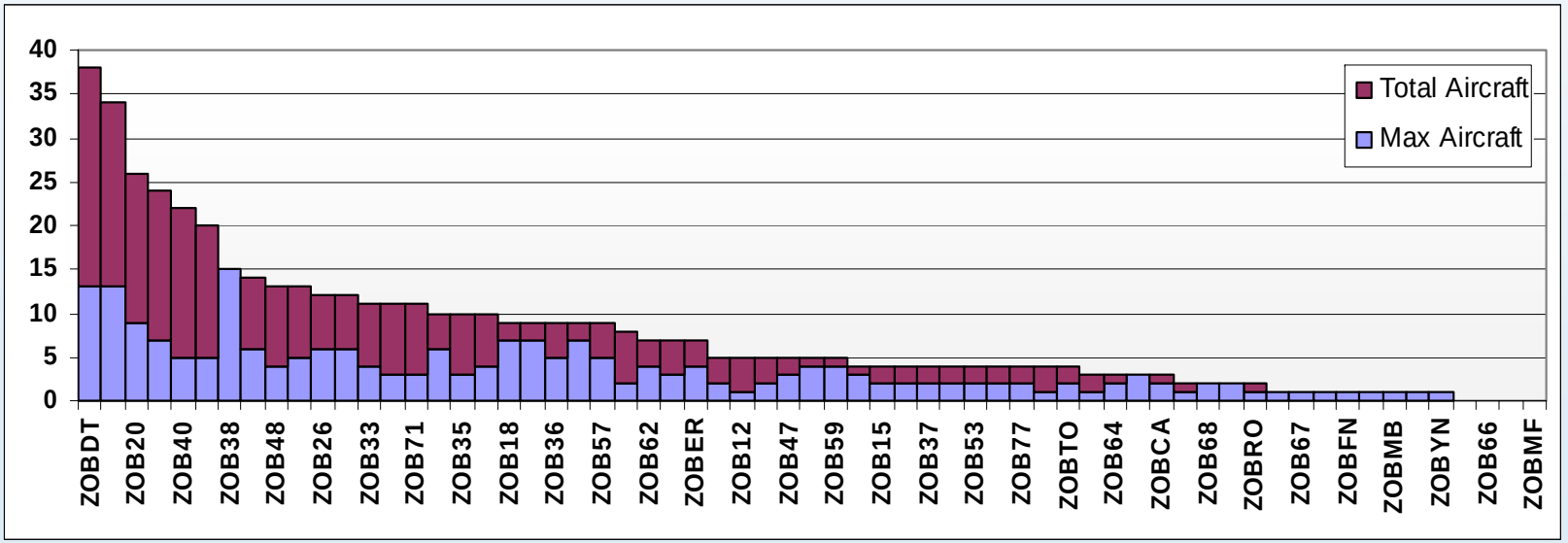
Mode 3 2V2D Operation



- The Mode 3 2V2D configuration provides 2 logical channels, or groups, in a 25 kHz VHF frequency
- Each group operates independently, with dedicated voice and data slots in the TDMA frame
- A single sector is assigned to a VDL Mode 3 group

Aircraft Traffic Load

- The flight traffic varies from sector to sector
  - The data traffic load is not distributed evenly amongst ground stations
- The busiest sectors:
  - Detroit TRACON, 38 total aircraft, up to 13 at a time
  - Sector 21, 34 total aircraft, up to 13 at a time
  - Sector 20, 26 total aircraft, up to 9 at a time



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Simulation Results

- The channels were lightly loaded
- Mode 3 has approximately half the load per channel as Mode 2 since it has 2 logical channels per frequency
- Mode 2 handoff delays are much shorter than those of Mode 3
  - This is expected due to the multiple MAC frames required to perform the handoff

	Mode 2	**Mode 3**
Number of Handoffs	325	319
Load per Channel	246 bps	129 bps
Mean HO Delay	0.20 s	2.23 s
95th Percentile HO Delay	0.47 s	3.21 s
99.9th Percentile HO Delay	0.82 s	4.66 s

The End

Any Questions?